Space Weather Technical Forecast

Issued on Sunday, 02 July 2023 at 13:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Occasional R1/R2 Radio Blackouts likely. Slight chance of G1/Minor Geomagnetic Storm intervals 04 Jul. Active Fluence expected throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Moderate with X-ray activity two M-class flares observed during the period, the peak an M2.0 event at 02/0235 UTC from developing region AR3359 in the far southeast. AR3354 in the northwest quadrant remains the largest and most magnetically complex region on the Earth-facing side of the Sun, and currently shows as an Fhc/Beta-Gamma-Delta composition. The group has elongated slightly through the period, with a slight overall increase in penumbral area in the lead portion of the group, but it retains a Mt Wilson delta spot. AR3359 continues to grow and has been the source of both recent low-level M-class flares. A beta-gamma configuration is present as well as perhaps a small delta spot, although there is still some foreshortening in available imagery, so this is not yet confirmed. The remaining sunspots, five numbered and one unnumbered are smaller and more magnetically simple.

Two M-flares from AR3359 at 01/2223 UTC and 02/0235 UTC appear to have resulted in separate, slow CMEs. These are still to be fully assessed for any Earth-directed component, but it is likely they will pass behind Earth.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, indicates a weak connection to CH18/+ in the far southwest, as the phi angle has been mostly positive (away from the Sun) throughout. The solar wind speed was initially between Elevated and Slightly Elevated levels around 480-510km/s, with an erratic declining trend to around 430-450km/s by the end of the period. The solar wind density was largely below average, but with a peak of 14ppcc at 01/1611 UTC. The IMF was weak throughout, 7nT or below, while the Bz was weak, and mainly positive. Geomagnetic activity was Quiet (Kp1-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels.

High energy electron flux (greater than 2MeV) was at mainly High levels, peaking at 2570pfu at 01/1650 UTC. The 24-hour integrated fluence has been on a slowly increasing trend and has been above the Active threshold throughout. A fluence of 1.29e8 was recorded at 02/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with occasional M-class flares likely and a slight chance of isolated X-class flares. The risk mostly coming from AR3354 in the northwest, but potentially also the emerging sunspots in the southeast or any returning regions through the forecast period.

Solar Wind / Geomagnetic Activity: A CME associated with a M3.8 flare on the 29 Jun may affect Earth as a glancing blow on day 3 (04 Jul). In the absence of any CME activity, the current slightly elevated fast wind from CH18/+ should slowly decline. A connection to small CH20/- is very uncertain, but may occur on day 3 (04 Jul). Any enhancements from this are expected to be

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weak, though may combine with the 29 Jun CME arrival at Earth.

Predominantly Quiet (Kp 0-2) geomagnetic activity should continue in the coming days, with only a slight chance of Active or G1/Minor Storm conditions on day 3 (04 Jul) from one or a combination of minor high-speed stream and CME effects.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to remain at Background levels, but with a daily slight chance of reaching the S1/Minor Storm level, mainly due to AR3354.

High energy electron flux (greater than 2MeV) is expected to remain at diurnally Moderate to High levels (above 1000 pfu) in the coming days, unless the CME that left the sun on 29 Jun arrives at Earth, or connection to a weak high-speed stream occurs on day 3 (04 Jul) and geomagnetic activity subsequently increases. From day 2 (03 Jul) the electron flux diurnal peaks should gradually reduce. The corresponding fluence is above the Active (1e8 integrated flux) threshold and expected to remain above this level on all days, with high confidence until day 4 (05 Jul), thereafter reducing to moderate confidence.

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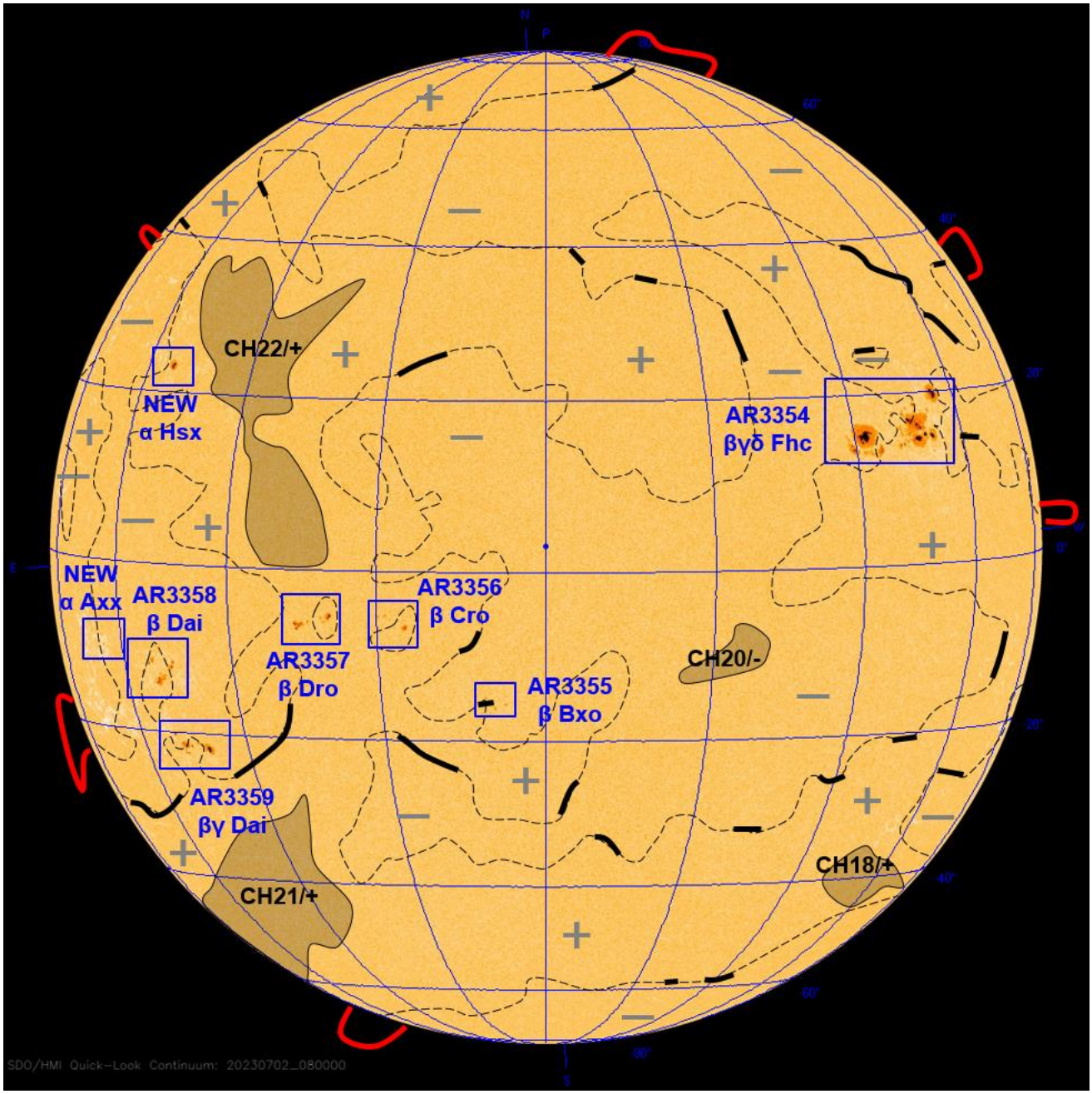
Figure 1. Solar Analysis Valid 02/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The CME that left the northeast quadrant of the Sun on 27 Jun appears to have missed Earth. A CME associated with the M3.8 flare from AR3354 on 29 Jun, may include an Earth-directed component, however, most, if not all of the ejecta appears directed above Earth. Any glancing arrival at Earth would be expected on day 3 (04 Jul). Two M-flares from AR3359 on 01 and 02 Jul appear to have resulted in separate, slow CMEs. These are still to be fully assessed for any Earth-directed component, but it is likely they will pass behind Earth.

Currently slightly elevated solar winds from the fast wind of CH18/+ in the far southwest should slowly decline in the coming days. A connection to small CH20/- in the southwest may occur on day 3 (04 Jul). Any enhancements from this, however, are expected to be weak, although may occur at a similar time to the possible arrival of the CME from 29 Jun at Earth. Otherwise no new or recurrent coronal holes feature in the period. It is therefore very possible that the current fast wind from CH18/+ continues undisturbed until it naturally declines, or is replaced by the onset of weak CH20/-. If this is the case then predominantly Quiet (Kp 0-2) geomagnetic activity should continue in the coming days, with only a slight chance of Active or G1/Minor Storm conditions on day 3 (04 Jul) from one or a combination of minor high-speed stream and CME effects.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
29/1415	Partial	Flare	N Centre disc	762 km/s	04/0600 UTC	Glancing blow, hence late arrival despite esimated speed

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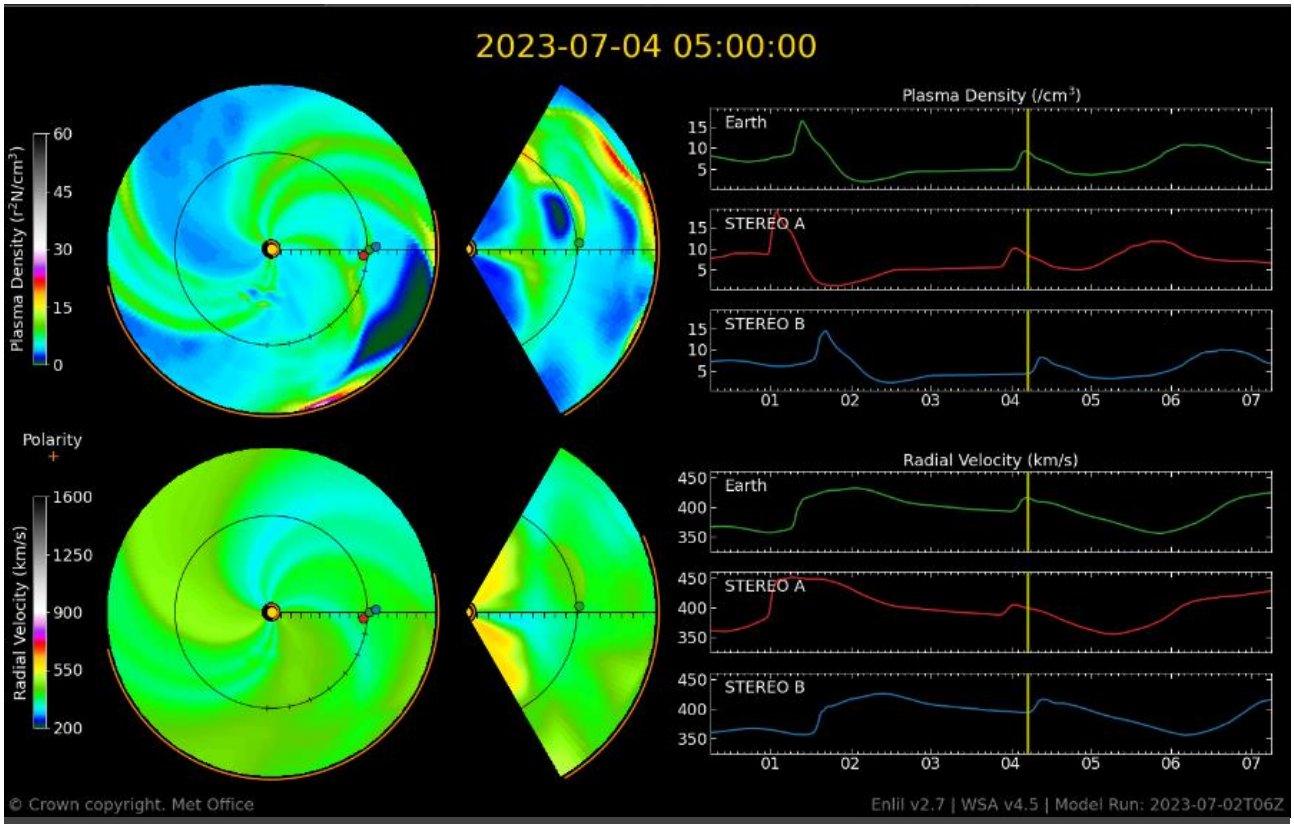
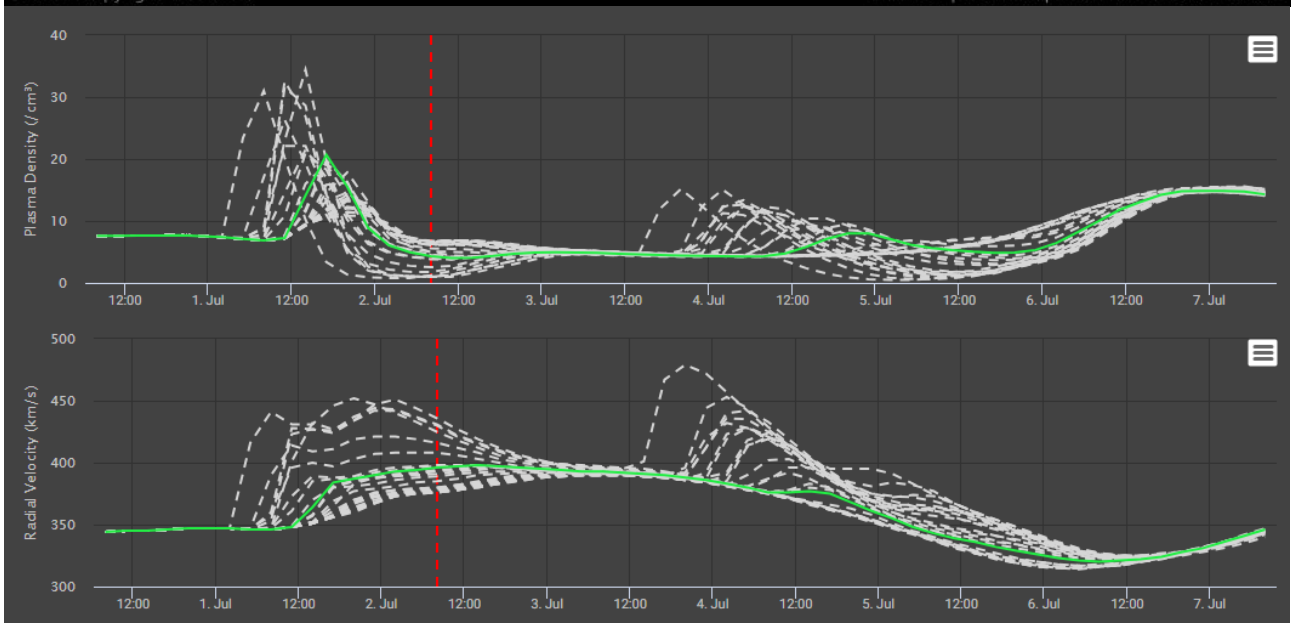
Figure 2: MOSWOC Enlil forecast and ensemble indicating possible glancing CME on 04 Jul.





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Radio Blackouts - X-Ray Flares:

Solar activity is Moderate with the largest flare of the period reaching M2.0 at 02/0235 UTC from AR3359 in the southeast. This region was also responsible for an M1.1 flare at 01/2223 UTC.

There are eight sunspot regions on the visible disc, with one of these currently unnumbered. AR3354 in the northwest remains the largest and most complex region. A delta spot is still evident and the penumbra surrounding the leading spot has grown slightly in size. Despite this, the region appears largely stable with no recent significant flares observed. The region is due to rotate over the western limb on day 4 (05 Jul). AR3359 a bipolar group in the southeast continues to grow with a mature, but small umbra on the lead spot and some smaller, emerging intermediate and trailer spots. A beta-gamma configuration is present as well as perhaps a small delta spot, although there is still some foreshortening in available imagery, so this is not yet confirmed. AR3358, also in the southeast has developed some new small spots as it continues to emerge. The remaining regions on the disc are relatively small and stable at this time.

Low to Moderate solar activity is expected with occasional M-flares likely, especially on days 1-3 (02-04 Jul) with AR3354 still on the disc. There is also a slight chance of activity becoming Strong with any isolated X-class flares. By day 4 (05 Jul) the flare risk is reduced, however, it may be revised given any development of sunspots, especially those emerging in the southeast, or from returning regions.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	75	75	75	40
Very Active	R3 to R5 X Class	No	10	10	10	5

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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at background levels and is most likely to remain so throughout the period. However, there is a slight chance of S1 levels being reached due to the potential for AR3354 to produce significant flares, and given its favourable location in the western hemisphere to be magnetically connected with Earth.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is likely to continue to follow its recent trend of diurnal variation between Moderate and High flux in the absence of any notable geomagnetic activity until possibly day 3 (04 Jul). At this time, one or a combination of minor high-speed stream (CH20/-) and CME (from 29 Jun) are low confidence to arrive at GEO, but either or both may suppress electron flux values. From day 2 (03 Jul) the electron flux diurnal peaks should gradually reduce.

Electron fluence is forecast to remain above the Active threshold on all days, with high confidence until day 4 (05 Jul), then becoming moderate confidence of continuing to exceed the threshold. MOSWOC REFM currently offers a good representation of existing and forecast conditions during the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	90	80	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 3: Latest GOES16 Electron flux and MOSWOC REFM forecast and recurrence output

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